**Drug use moderates associations between location of sex and unprotected anal intercourse in men who have sex with men: nested cross-sectional study of dyadic encounters with new partners**

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**ABSTRACT**

**Objectives.** This nested cross-sectional study of dyadic sexual encounters with new male partners reported by men living in England who have sex with men tested moderation between drug use and location of sex in associations with unprotected anal intercourse (UAI).

**Methods.** Data were drawn from two waves of a longitudinal monthly internet survey of men living in England who have sex with men conducted in 2011. Using generalised estimating equations and logit link, we tested the relationship with UAI of any respondent drug use before sex, specific respondent drug use before sex, location of sex (distinguishing private, sex-on-premises venue, and cruising locations) and location-drug use interactions.

**Results.** Any respondent drug use (OR 1.57, 95% CI [1.31, 1.88]) was associated with increased odds of UAI. Relative to encounters in private locations, encounters in sex-on-premises venues (0.69, [0.52, 0.91]), but not cruising locations, were associated with decreased odds of UAI. Any respondent drug use, respondent use of poppers and respondent use of alcohol were each associated with increased UAI in sex-on-premises venues.

**Discussion.** This analysis presents evidence of moderation between drug use and location of sex in associations with UAI. Though this analysis used a large sample, it relied on community-recruited respondents. Our findings may reflect either ‘totalising’ effects of drug use across venues, or site-specific use of drugs as a mechanism for cognitive escape. Additional qualitative research is necessary to understand these findings in context.

**INTRODUCTION**

 A growing body of research aims to understand the situational characteristics associated with sexual risk behaviours during sex between men. In particular, both location of sex and concurrent drug use have drawn attention in analyses examining event-level associations with unprotected anal intercourse (UAI). Some studies point to significant associations [1,2] between location of sex and UAI during sex between men, while others do not [3–5], though most evidence on this association is not recent. Moreover, though a recent systematic review found that encounters with partners met via the internet were associated with increased risk as compared to encounters with partners met in sex-on-premises venues [6], this review did not examine or compare locations of sex specifically. A recent systematic review of event-level studies of sex between men [7] found only weak evidence for a general association between drug use and UAI, though evidence is strong for some specific drugs, including binge alcohol drinking and crystal methamphetamine. Another systematic review found evidence for associations between poppers use and increased risk of HIV transmission generally, due both to encounter-level sexual risk and biological changes in smooth muscle tissue associated with poppers use [8], though this evidence is not recent. Other person-level studies have found that use of poppers is associated with increased sexual risk behaviour [9–11], possibly due to the role of poppers in facilitating receptive anal intercourse via smooth muscle dilatation. A question that has not been substantively explored in the event-level data is moderation between drug use and location of sex in associations with sexual risk behaviour. That is to say, to what degree is the relationship between location of sex and sexual risk conditional on drug use? Qualitative evidence [12] suggests that drug use may moderate the association between location of sex and sexual risk behaviour.

 This analysis used data on encounters with new partners from an internet-based cohort study of MSM living in England to test univariate associations between UAI and both drug use, measured both as any drug use by respondent and specific drugs used by respondent, and location of sex. We planned *a priori* to test how drug use moderates the association between location of sex and UAI.

**METHODS**

 This cross-sectional analysis uses data from The Sigma Panel, a longitudinal monthly internet survey of MSM living in England conducted between January 2011 and January 2012. A detailed survey methodology is published elsewhere [13]. The analysis draws from two of the monthly surveys (M1 and M3, sent on 1st February and 1st April) in which a set of questions were asked about the respondent’s most recent sexual encounter with a new partner or partners. To eliminate confounding based on multiple partners, this analysis is restricted to dyadic encounters. We included all eligible encounters reported at either time point. The unit of analysis was sexual encounters. Anal intercourse (AI) and condom use were asked separately. We compared encounters that included UAI (i.e. both AI and inconsistent or no condom use) against encounters with all other types of non-UAI sexual behaviour.

 Questions about drug use included both a question about use of poppers during sex and a question phrased as ‘Did you use any alcohol or drugs before sex?’ followed by a list of 14 drugs (alcohol / Viagra®, Cialis®, Levitra® or other drugs that help to keep an erection / cannabis / ecstasy (E, XTC, MDMA) / amphetamine (speed) / crystal methamphetamine (crystal, meth, Tina) / heroin / mephedrone (4-MMC, meow, methylone, bubbles) / GHB, GBL (liquid ecstasy) / ketamine / LSD / cocaine / crack cocaine / any other drug). Two sets of variables were constructed from this: first, a binary variable recording any drug use, and second, a set of six binary variables addressing specific drug use, namely poppers use, alcohol use, erectile dysfunction medication use, cannabis use, chemsex drug use (i.e. crystal methamphetamine, mephedrone, GHB, or ketamine, as suggested by qualitative evidence [12]), and ‘uppers’ use (i.e. ecstasy, amphetamine, or cocaine). Additionally, respondents were asked where the sex occurred and then invited to choose from a checklist of nine options (my (or our) place / his place / a friend’s place / a backroom of a bar, gay sex club, a public gay sex party / a gay sex party in a private home / a gay sauna / a porn cinema / a cruising location (street, roadside service area, park, beach, lavatory) / elsewhere). Location of sex was recoded into homes (my place, his place, a friends place, private home); sex-on-premises venues (back room etc., sauna, cinema); and cruising locations. This categorisation reflects key distinctions between locations of sex, including the difference between public sex venues that require payment and settings that do not require payment.

 We first estimated three models: one including the binary variable for any drug use, one including the six binary variables for specific drug use, and one including the three-category variable for location of sex. We included all six binary variables for specific drug use in the same model to better isolate associations between specific drugs and UAI. We then estimated two multivariate models: one including variables for any drug use and for location of sex, and one including variables for specific drug use and for location of sex. Finally, to examine moderation of location of sex by drug use in associations with UAI, we undertook moderator analyses by re-estimating the two models including interaction terms ‘crossing’ drug use and location of sex [14]. Because of issues with model convergence, we did not test moderation between all specific drug use variables and location of sex at once. Instead, we tested moderation between poppers and location of sex and between alcohol and location of sex sequentially while controlling for all other specific drug use variables. We chose poppers and alcohol because these were the most commonly used drugs. We tested our moderation models for robustness by also including a vector of person-level confounds (i.e. age, education, ethnic group and sexual orientation).

 All models were estimated as generalised estimating equations with logit link and exchangeable correlation matrices to correct for multiple encounters per respondent. Missing data were less than 5% in all analyses and handled with pairwise deletion. Wald tests captured the overall significance of each model in explaining variation in the dependent variable. Odds ratios greater than 1 indicated increased odds of UAI. We present moderation effects in terms of the multiplicative effect of drug use on odds of sexual risk within each location of sex.

**RESULTS**

In total, 1,034 men reported two eligible encounters and another 845 reported one, giving 2,913 encounters reported by 1,879 respondents. On average, respondents were 42.2 years of age (SD=11.9). The majority were White British (81.7%) and identified as gay (84.3%). Exactly half reported a university degree, and 35.1% lived in London. In the enrolment survey, almost a quarter of respondents reported having diagnosed HIV.

Most encounters (82.3%) occurred in homes, 12.9% occurred in sex-on-premises venues and 4.8% occurred in cruising locations. Across all new partner encounters, 21.2% included UAI and 51.5% involved drug use by the respondent. See Table 1 for encounter-level descriptive statistics.

**Table 1.** Characteristics of included encounters.

|  |  |
| --- | --- |
| **Variable** | **% (n)** |
| **Unprotected anal intercourse** | **21.2 (618)** |
| **Any drug use** | **51.5 (1,498)** |
| Poppers | 22.1 (635) |
| Alcohol | 30.1 (874) |
| Erectile dysfunction medications | 10.7 (310) |
| Cannabis | 3.8 (111) |
| Chemsex drugs (crystal meth, mephedrone, GHB, ketamine) | 4.2 (121) |
| Uppers (ecstasy, amphetamine, cocaine, crack) | 3.9 (113) |
| **Location of sex** |  |
| Home | 82.3% (2,395) |
| Sex-on-premises venue | 12.9% (375) |
| Cruising | 4.8% (139) |
| **Drug use and location of sex** |  |
| No drug use and home | 38.2 (1,107) |
| Any drug use and home | 44.2 (1,281) |
| No drug use and sex-on-premises venue | 6.9 (199) |
| Any drug use and sex-on-premises venue | 6.0 (175) |
| No drug use and cruising location | 3.4 (100) |
| Any drug use and cruising location | 1.3 (38) |

In a univariate model, any drug use was associated with increased odds of UAI (OR 1.57, 95% CI [1.31, 1.88]) (see Table 2). When specific drug use variables were entered as a block, use of poppers (1.78, [1.44, 2.20]), chemsex drugs (2.10, [1.35, 3.28]) and uppers (1.62, [1.02, 2.55]) were each associated with increased odds of UAI. Relative to encounters at home, encounters in sex-on-premises venues (0.69, [0.52, 0.91]) were associated with decreased odds of UAI, though encounters in cruising locations were not significantly different from encounters at home in terms of odds of UAI. Associations were similar in magnitude, precision and significance in multivariate models testing any drug use with location of sex and specific drug use with location of sex as compared to univariate models.

**Table 2.** Univariate and multivariate associations between unprotected anal intercourse, drug use and location of sex during sex between new male partners

|  |  |  |
| --- | --- | --- |
| **Variable** | **Univariate models** | **Multivariate models** |
| OR (95% CI) | n=2,897 in 1,874 groupsOR (95% CI) | n=2,858 in 1,861 groupsOR (95% CI) |
| Intercept |  | 0.14\*\*\* (0.10, 0.19) | 0.22\*\*\* (0.19, 0.26) |
| Any drug use by respondent | 1.57\*\*\* (1.31, 1.88) | 1.57\*\*\* (1.31, 1.88) |  |
| Poppers | 1.78\*\*\* (1.44, 2.20) |  | 1.78\*\*\* (1.44, 2.21) |
| Alcohol | 1.03 (0.84, 1.25) |  | 1.02 (0.83, 1.25) |
| Erectile dysfunction medication | 1.07 (0.81, 1.42) |  | 1.10 (0.83, 1.47) |
| Cannabis | 1.26 (0.80, 1.99) |  | 1.26 (0.79, 1.99) |
| Chemsex drugs | 2.10\*\* (1.35, 3.28) |  | 2.08\*\* (1.33, 3.24) |
| Uppers | 1.62\* (1.02, 2.55) |  | 1.59\* (1.00, 2.53) |
| Location of sex |  |   |  |
| Home | Reference | Reference | Reference |
| Sex-on-premises venue | 0.69\*\* (0.52, 0.91) | 0.71\* (0.53, 0.95) | 0.70\* (0.53, 0.94) |
| Cruising location | 0.99 (0.66, 1.47) | 1.11 (0.74, 1.66) | 1.13 (0.75, 1.70) |
| **Wald test (χ2, df, *p*-value)** |  | 29.96, 3, <0.0001 | 74.37, 8, <0.0001 |

\**p*<0.05, \*\**p*<0.01, \*\*\**p*<0.001

 Moderation models revealed a statistically significant interaction term between sex in sex-on-premises venues and any respondent drug use (OR 2.23, 95% CI [1.21, 4.09]) that was associated with increased odds of UAI (see Table 3). That is, use of substances in sex-on-premises venues was associated with a greater increase in odds of sexual risk than use of substances in sexual encounters at home. Poppers use also significantly moderated the association between sex-on-premises venues and sexual risk, with similar interpretation. Alcohol use appeared to moderate sexual risk in sex-on-premises venues, but this association was marginally significant (i.e. *p*<0.10). Sexual risk in encounters in cruising locations did not appear to be significantly moderated by drug use. Interpretation of these moderation models in terms of significance and magnitude was not affected by inclusion of person-level confounders, with the exception of alcohol use in sex-on-premises venues, the interaction term for which was similar in magnitude (OR 1.93) but statistically significant (*p*<0.05).

**Table 3.** Moderation models testing associations between unprotected anal intercourse, drug use and location of sex during sex between new male partners

|  |  |  |  |
| --- | --- | --- | --- |
| **Variable** | **Any drug use** | **Poppers useb** | **Alcohol useb** |
| OR (95% CI) | OR (95% CI) | OR (95% CI) |
| Home | Reference | Reference | Reference |
| Drug usea | 1.47\*\*\* (1.21, 1.79) | 1.61\*\*\* (1.28, 2.03) | 0.98 (0.79, 1.21) |
| Sex-on-premises venues | 0.43\*\* (0.26, 0.72) | 0.54\*\* (0.37, 0.79) | 0.60\*\* (0.42, 0.85) |
| Sex-on-premises venues X drug use | 2.23\* (1.21, 4.09) | 2.13\* (1.15, 3.93) | 1.81 (0.97, 3.40) |
| Cruising locations | 1.21 (0.74, 1.97) | 1.03 (0.64, 1.65) | 1.18 (0.77, 1.81) |
| Cruising locations X drug use | 0.73 (0.30, 1.75) | 1.44 (0.55, 3.78) | 0.64 (0.17, 2.43) |
| **Wald test (χ2, df, *p*-value)** | 33.52, 5, <0.0001 | 78.60, 10, <0.0001 | 77.54, 10, <0.0001 |

\**p*<0.05, \*\**p*<0.01, \*\*\**p*<0.001

a Because moderation models present ‘conditional’ estimates of regression coefficients, the strict interpretation of this coefficient is the increment in sexual risk associated with drug use in sexual encounters at home.

**b** These models included additional specific drug use variables.

 To facilitate interpretation of moderation effects, we calculated marginal probabilities of UAI under different location-drug use combinations (see Figure 1; raw probabilities are included in Supplementary File 1). Predicted UAI probabilities under any drug use showed that UAI probability under conditions of no drug use was 19% in homes, 9% in sex-on-premises venues and 22% in cruising locations. Yet under conditions of drug use, UAI probability was 25% in both homes and sex-on-premises venues and 23% in cruising locations. Put otherwise, the increase in probability of UAI under drug use compared to no drug use was more than two and a half times higher in sex-on-premises venues as compared to home locations.

 Similar patterns were found for poppers use, where the difference in predicted UAI probabilities between drug use and no drug use in home encounters was 8% whereas this difference was 19% in sex-on-premises venues (see Supplementary File 1 for graphs). There was no difference (i.e. 0%) between encounters with alcohol use and encounters without alcohol use at home, though this difference was 7% in sex-on-premises venues.

**DISCUSSION**

 This analysis presents new evidence of encounter-level associations between drug use and sexual risk and between location of sex and sexual risk for a population in which encounter-level sexual risk is poorly understood, namely MSM living in England. This analysis also presents new evidence of moderation between drug use and location of sex in their associations with UAI during sex between men. Specifically, this analysis finds that any drug use, poppers use, chemsex drug use and uppers use are associated with increased sexual risk. Moreover, relative to encounters with new partners in homes, encounters with new partners in sex-on-premises venues are associated with decreased odds of UAI. In moderation models, any drug use was associated with increases in sexual risk in both home venues and sex-on-premises venues, though drug use was associated with a greater increase in sexual risk in sex-on-premises venues.

 Strengths of this study include a large sample of MSM and the use of a robust analytic method. A key limitation was the use of a non-probability sample. Convenience samples report higher risk-taking than probability samples [15]. Capturing the last encounter with a new partner may also not form a representative sample of dyadic encounters, particularly if the last encounter was preceded by several other encounters in a short time, as may be the case in sex-on-premises venues. Restriction of this analysis to dyadic new partner encounters was a strength, as it reduced confounding based on sexual history with numbers of partners. However, this does mean that the results presented here are not generalisable to multipartner encounters, the frequency of which represents an important characteristic of sex-on-premises venues. Additional limitations of this analysis include a relatively small number of encounters in cruising locations, which limits our ability to understand moderation of sexual risk in encounters in these locations. We were also unable to explore moderation of associations between location of sex and sexual risk by other classes of drugs, including drugs associated with chemsex. Though poppers and alcohol are key drugs of interest because of the frequency of their use, drugs associated with chemsex continue to rise in public health importance in urban areas of the United Kingdom [12,16]. Future research should seek to understand moderation of sexual risk by these emergent drugs.

 Though evidence from a recent systematic review suggests that venue of partner meeting is associated with sexual risk [6], past studies [2,4,5,17] have disagreed on the direction and statistical significance of the association between location of sex and UAI. In particular, this systematic review has shown that encounters with internet-met partners are more likely to involve sexual risk than encounters with partners met in sex-on-premises venues or other social settings [6]. The current findings nuance and extend the conclusions of this systematic review by focusing specifically on location of sex. It is plausible—as reflected by the univariate and multivariate models—that encounters in sex-on-premises venues may be less likely to include UAI than in homes and cruising grounds, while encounters with drug use shared remarkably similar probabilities of UAI across private locations and sex-on-premises venues. On the one hand, this may reflect a ‘totalising effect’ of drug use—that regardless of location, the use of drugs is uniformly associated with UAI. On the other hand, the contrast in probabilities of UAI under conditions of no drug versus drug use in sex-on-premises venues could suggest a mechanism of disinhibition that undermines precautionary intentions in a highly stimulating sexual context, or of planned drug use for intended cognitive escape [18].

 Our findings suggest that interventions that aim to reduce drug use in both home locations and sex-on-premises venues are likely to reduce sexual risk behaviours in those venues. Further research could aim to duplicate these findings in different samples, to extend these analyses to within-subjects comparisons, and to explore the impact of public health interventions on different locations of sex. Qualitative research is necessary to understand the differences in predicted probabilities across venues and between encounters with and without drug use, and the feasibility and acceptability of interventions.

**KEY MESSAGES**

* Previous observational studies have noted associations between location of sex and drug use and sexual risk behaviour in men who have sex with men.
* In this sample of dyadic new partner encounters, drug use moderated location of sex in associations with sexual risk behaviour.
* Drug use is associated with increased sexual risk in both home encounters and in sex-on-premises venues, but not in cruising locations.

**WORD COUNT** 2,302 words, without abstract, references or key messages

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**CONTRIBUTIONS**

PW conceived the Sigma Panel and its technical specification. FH coordinated the panel study. FH, CB and DR designed the monthly questionnaires. DR and FH were responsible for communications with respondents, the technical implementation of the panel and data management and cleaning. GJMT and CB planned the data analysis. GJMT performed the data analysis. GJMT drafted the paper and PW, FH and CB edited it. All authors agreed on the final manuscript.

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**COMPETING INTERESTS**

None.

**ETHICS APPROVAL**

The survey was conducted with the approval of the London School of Hygiene and Tropical Medicine Ethics Committee (approval number 5834). Approval for this specific analysis was granted by the Department of Social Policy and Intervention Research Ethics Committee at the University of Oxford.

**FIGURES**

**Figure 1.** Predicted probabilities for UAI under drug use-location of sex combinations.

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